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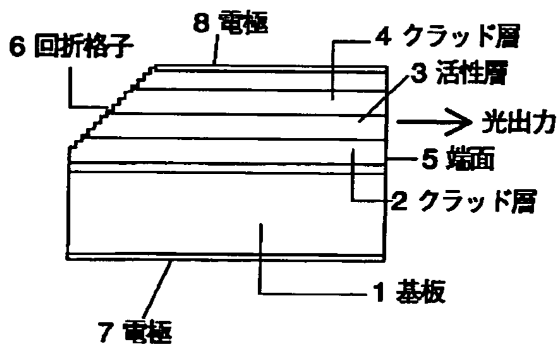
(54)【発明の名称】　半導体レーザ

(57)【要約】
【目的】　半導体レーザの変調歪特性を改善する。
【構成】　端面５と回折格子６で共振器が構成され、レーザ光は端面５から出力される。このようにすれば、回折格子６から電極７に垂直に反射される波長が選択され、単一軸モードで発振する。また、光導波路での電界強度分布が均一になり、アナログ変調歪特性が改善される。



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【特許請求の範囲】

【請求項1】　半導体基板上に形成された活性層とこの活性層を挟むクラッド層とからなる光導波路と、前記光導波路の軸に対してほぼ90°の角度をなすように形成された端面と、前記光導波路の軸に対してほぼ45°の角度をなすように設けられ、該光導波路を間に挟んで前記端面にほぼ45°の角度をなして設けられている回折格子とから構成されることを特徴とする半導体レーザ。

【請求項2】　基板側の電極が少なくとも2つの部分に分割して形成されていることを特徴とする請求項1に記載の半導体レーザ。

【請求項3】　前記クラッド層を半導体多層膜により構成したことを特徴とする請求項1または請求項2に記載の半導体レーザ。

【請求項4】　前記端面に低反射率のコーティングを施したことを特徴とする請求項1乃至3に記載の半導体レーザ。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は半導体レーザに関し、特に相互変調歪特性に優れる半導体レーザに関する。

【0002】

【従来の技術】サブキャリア多重光伝送方式などに用いられるアナログ変調用光源には、高効率で相互変調歪の小さい単一軸モード半導体レーザが要求されている。例えば移動通信システム用では3次相互変調歪（3rd intermodulation distortion；IMD_3）が十分に小さい素子が要求されている。分布帰還型半導体レーザ（DFBレーザ）は単一モード性が良好であり、アナログ変調用光源に用いられつつあるが、通常のDFBレーザでは共振器方向のキャリアおよび電界強度分布不均一のために電流－光出力（I－L）特性の線形性が不十分で相互変調歪特性も優れたものではなかった。

【0003】ところで、平成4年秋季第53回応用物理学会学術講演会16p－V－1では、45°の反射面と半導体多層膜を用いた面発光レーザが小川らにより発表されている。これは、2つの45°の反射面と活性層と分布反射器から形成され、基板側からレーザ光が出射される構造である。

【0004】

【発明が解決しようとする課題】しかし、従来の半導体レーザは面発光を目的としたものであり、光通信およびアナログ変調を目的としたものではなかった。

【0005】本発明の目的は、単一軸モード性を損なうことなく半導体レーザの共振器内部の電界強度分布の均一性を向上させ、電流－光出力特性の線形性および変調歪特性を改善することにある。

【0006】

【課題を解決するための手段】本発明のアナログ変調用半導体レーザは、半導体基板上に形成されたと活性層とこの活性層を挟むクラッド層とからなる光導波路と、前記光導波路の軸に対してほぼ90°の角度をなすように形成された端面と、前記光導波路の軸に対してほぼ45°の角度をなすように設けられ、該光導波路を間に挟んで前記端面にほぼ45°の角度をなして設けられている回折格子とから構成されることを特徴とする。

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【0007】また、基板側の電極が少なくとも2つの部分に分割して形成されていることを特徴とする。

【0008】また、前記クラッド層を半導体多層膜により構成したことを特徴とする。

【0009】さらに、前記端面に低反射率のコーティングを施したことを特徴とする。

【0010】

【作用】図面を参照して本発明の原理を説明する。

【0011】図1は本発明になる半導体レーザの構造の一例を示す図である。図1において、共振器は端面5と回折格子6と電極7で構成され、レーザ光は端面5から出力される。

【0012】このような構造にすると回折格子6から基板側電極7に垂直に反射される波長で単一軸モード発振をする。

【0013】また、光導波路と半導体多層膜の結合に回折格子を用いているから、従来の半導体レーザのように45°の面を用いるのと比較すると反射光の広がりが小さくなる。したがって、本発明の構造の半導体レーザでは、共振器の損失が小さくなり閾値電流が低減される。

【0014】図2は本発明の半導体レーザと通常のDFBレーザの共振器内部の電界強度の分布を示したものである。

【0015】通常のDFBレーザの場合、図2（b）のように共振器方向の電界強度が不均一である。これに対し、本発明の半導体レーザでは図2（a）に示すように共振器内部の電界強度分布の均一性が改善される。したがって、本発明の半導体レーザにおいては電流－光出力特性の線形性が向上し、変調歪が低減される。

【0016】また、電極7を基板1の一部分だけに形成すれば発振波長の選択性が強くなり、単一モード性が向上する。

【0017】また、基板側1のクラッド層2を半導体多層膜層にすることによっても波長の選択性が強くなり単一軸モード性が向上する。

【0018】さらに、他方のクラッド層4を半導体多層膜により構成することにより、活性層3で発生した自然放出光が活性層3に戻される効果（フォトンリサイクリング効果）により発振閾値電流が低減される。

【0019】また、回折格子6を形成しない方の端面5に低反射率のコーティングを施すことにより効率が改善される。

【0020】

【実施例】以下に、本発明の一実施例である1．3μm帯半導体レーザを図面を参照して説明する。

【0021】図3は第1の実施例の製造工程を示す図である。

【0022】図3（a）に示すように、n－InP基板10上にMOVPE法によりn－InPバッファ層11を2000Åの厚さに形成し、1．2μm波長組成のn－InGaAsP（厚さ1024Å）とn－InP（1024Å）とを1周期とするDBR層12を約3μm形成し、1．3μm波長組成のInGaAsP活性層13、さらにp型のDBR層14を約2μm、p－InGaAsキャップ層15を2000Å成長する。

【0023】次いで、図3（b）に示すようにホトレジスト16を塗布し、露光、現像、エッチングにより45°の面17を形成する。

【0024】さらに、図3（c）に示すように、ホトレジスト18を塗布し、45°の面の部分だけにホトレジストが残るように露光、現像した後、p側電極19及びn側電極20を蒸着する。

【0025】次に、図3（d）に示すように、リフトオフにより45°の面の電極を除去し、再び45°の面に残ったホトレジスト21を用い、干渉露光法により回折格子のパターンを形成する。

【0026】この後、図3（e）に示すようにエッチングにより回折格子22を形成する。さらに、全面を露光、現像し残ったホトレジストを除去する。

【0027】この後、図3（e）の点線で示す部分で素子を劈開する。

【0028】この素子は1．31μmで発振し、試作した素子をモジュール化し、2信号で3次相互変調歪を測定した結果、平均ファイバー出力5mW、変調度20％で－80dBcと良好な歪特性を得ることができた。

【0029】この素子の端面に1％以下の反射率のコーティングを施した場合、効率が従来の半導体レーザの20％以上改善された。

【0030】次に第2の実施例について図4を参照して説明する。

【0031】図4は基板1側の電極37を2つの部分から構成し、電極37を基板1の一部分だけに構成し、光の反射に寄与する部分を狭くした構造である。このような素子を図3に示した第一の実施例の場合と同様にして作製したところ、従来の半導体レーザの場合、副モード抑圧比が25dBcであったのに対して30dBcとなり、発振の単一モード性が改善された。

【0032】さらに、図5に本発明の第3の実施例を示す。これは、活性層3より基板1側のクラッド層42を半導体多層膜にした構造である。この素子の副モード抑圧比を測定したところ28dBcであり、従来の半導体レーザよりも単一モード性が向上した。

【0033】また、図6に本発明の第4の実施例を示す。これは、活性層3の両側のクラッド層42，43を半導体多層膜にした構造である。このような素子を作製したところ、発振閾値電流が20％低減された。また、副モード抑圧比は30dBcとなった。

【0034】

【発明の効果】本発明によれば、低歪のアナログ変調用半導体レーザを提供することが可能となる。

【図面の簡単な説明】

【図1】本発明になる半導体レーザの原理的構造を示す図。

【図2】本発明になるレーザと従来のレーザとの電界強度分布を示す図。

【図3】本発明の第1の実施例の製造工程を説明するための図。

【図4】本発明の第2の実施例の構造を模式的に示す断面図。

【図5】本発明の第3の実施例の構造を模式的に示す断面図。

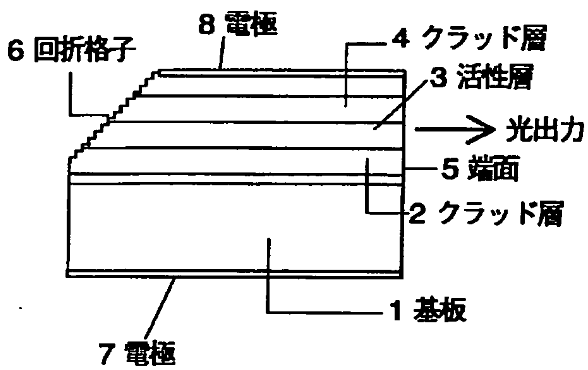
【図6】本発明の第4の実施例の構造を模式的に示す断面図。

【符号の説明】

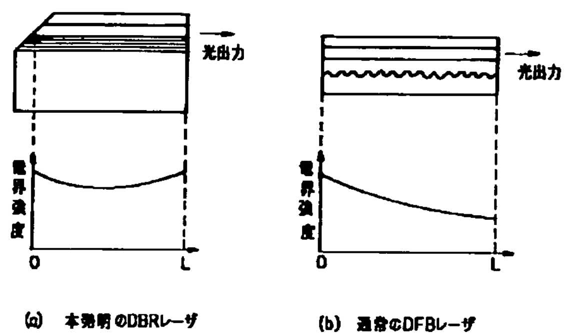
1　基板
2　クラッド層（基板側）
3　活性層
4　クラッド層（成長層側）
5　導波路の軸に垂直な端面
6　導波路の軸に45°の角度をなす面に形成された回折格子
7　基板側電極
8　成長側電極
10　n－InP基板
11　n－InPバッファ層
12　n－InPクラッド層
13　InGaAsP活性層
14　p－InPクラッド層
15　p－InGaAsキャップ層
16　ホトレジスト
17　45°の面
18　ホトレジスト
19　電極
20　電極
21　ホトレジスト
22　回折格子
31　n－InP基板
32　n－InPクラッド層
33　InGaAsP活性層
34　p－InPクラッド層
35　端面
36　回折格子
37　電極

38 電極
42 n型DBR層
43 p型DBR層

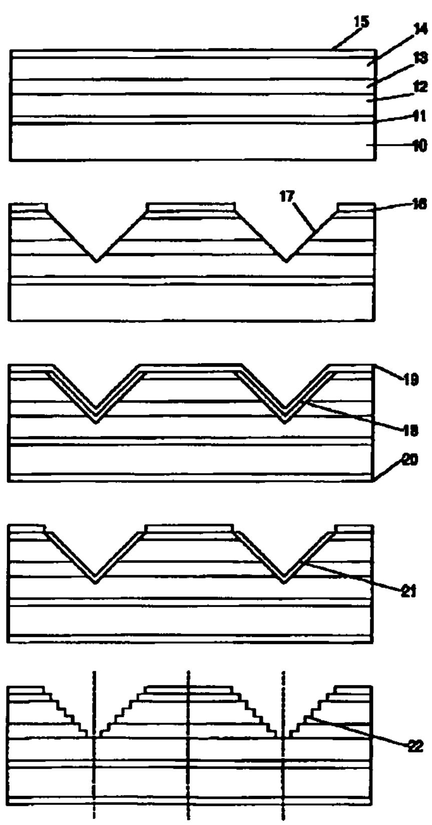
【図1】



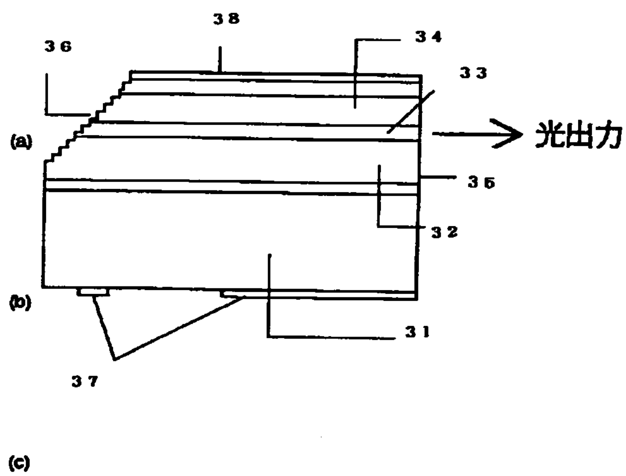
【図2】



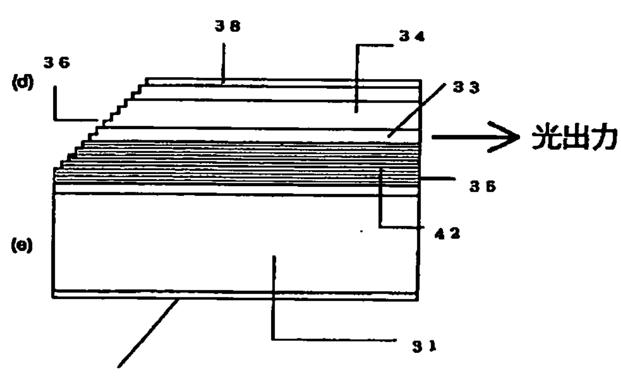
【図3】



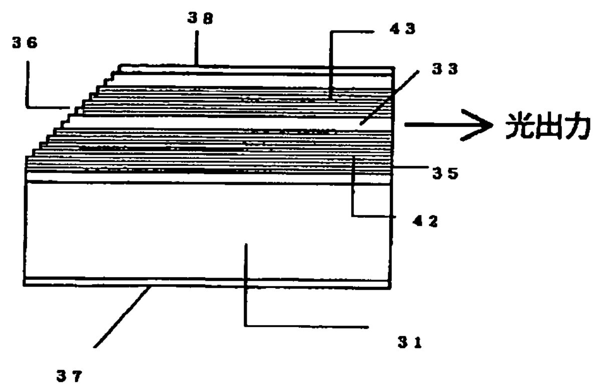
【図4】



【図5】



【図6】



PATENT ABSTRACTS OF JAPAN

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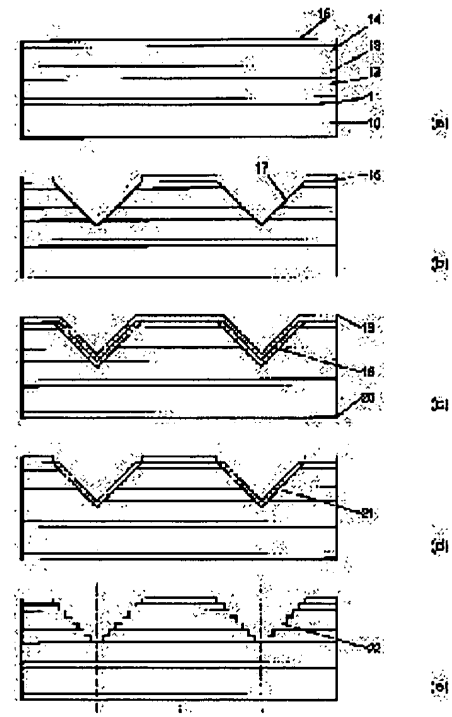
(54) SEMICONDUCTOR LASER

(57)Abstract:
PURPOSE: To improve the uniformity of a field strength distribution in the interior of the resonator of a semiconductor laser by a method wherein diffraction gratings are provided at an angle of roughly 45° to the axes of optical waveguides and at an angle of roughly 45° to the end face of the resonator, interposing the optical waveguides between them.
CONSTITUTION: An N-type InP buffer layer 11 is formed on an N-type InP substrate 10, a DBR layer 12, which is formed by forming alternately an N-type InGaAsP layer and an N-type InP layer in one period, is formed and an InGaAsP active layer 13, a P-type DBR layer 14 and a P-type InGaAs cap layer 15 are grown. Then, a photoresist 16 is applied and surfaces 17 at an angle of 45° to the end face of a resonator are formed by exposure, developing and etching. Moreover, after a photoresist 18 is applied and the photoresist 18 is exposed and developed in such a way that it is left only on the parts of the surface at an angle of 45°, a P side electrode 19 and an N side electrode 20 are deposited. Then, parts, which are deposited on the surfaces at an angle of 45°, of the electrode 19 are removed by a lift-off method and diffraction gratings 22 are formed using again a photoresist 21 left on the surface at an angle of 45°.



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[Date of extinction of right]	08.08.2002

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] Especially this invention relates to the semiconductor laser which is excellent in an intermodulation distortion property about semiconductor laser.
[0002]
[Description of the Prior Art] It is efficient to the light source for analog modulation used for a subcarrier multiplex optical transmission method etc., and the small single axial-mode semiconductor laser of intermodulation distortion is demanded of it. For example, the object for migration communication system requires the component with the 3rd intermodulation distortion (3rd intermodulation distortion;IMD3) small enough. Although single mode nature is good and was used for the light source for analog modulation, the usual DFB laser of the linearity of a current-optical output (I-L) property was [distribution feedback mold semiconductor laser (DFB laser)] inadequate because of the carrier of the direction of a resonator, and the field strength distribution ununiformity, and it was not what was excellent also in the intermodulation distortion property.
[0003] By the way, the surface emission-type laser which used a 45-degree reflector and semi-conductor multilayers in Heisei 4 by 53rd time Japan Society of Applied Physics academic lecture meeting 16 p-V -1 of autumn is announced by brooks. This is the structure where it is formed from two 45-degree reflectors, barrier layers, and distribution reflectors, and outgoing radiation of the laser beam is carried out from a substrate side.
[0004]
[Problem(s) to be Solved by the Invention] However, the conventional semiconductor laser was not a thing [aiming at optical communication and analog modulation] aiming at field luminescence.
[0005] The purpose of this invention raises the homogeneity of the field strength distribution inside the resonator of semiconductor laser, without spoiling single axial-mode nature, and is to improve the linearity of a current-optical output property, and a modulation distortion property.
[0006]
[Means for Solving the Problem] The optical waveguide which consists of a cladding layer which sandwiches a barrier layer and this barrier layer as the semiconductor laser for analog modulation of this invention was formed on the semi-conductor substrate, The end face formed so that the include angle of about 90 degrees might be made to the shaft of said optical waveguide, It is characterized by consisting of diffraction gratings which are prepared so that the include angle of about 45 degrees may be made to the shaft of said optical waveguide, make the include angle of about 45 degrees to said end face, and are prepared in it on both sides of this optical waveguide in between.
[0007] Moreover, it is characterized by dividing and forming the electrode by the side of a substrate in at least two parts.
[0008] Moreover, it is characterized by constituting said cladding layer by semi-conductor multilayers.
[0009] Furthermore, it is characterized by performing coating of a low reflection factor to said end face.
[0010]
[Function] The principle of this invention is explained with reference to a drawing.
[0011] <u>Drawing 1</u> is drawing showing an example of the structure of semiconductor laser which becomes this invention. In <u>drawing 1</u> , a resonator consists of an end face 5, a diffraction grating 6, and an electrode 7, and a laser beam is outputted from an end face 5.
[0012] If it is made such structure, a single axial-mode oscillation will be carried out on the wavelength reflected at right angles to the substrate lateral electrode 7 from a diffraction grating 6.
[0013] Moreover, since the diffraction grating is used for association of optical waveguide and semi-conductor multilayers, as compared with using a 45-degree field like the conventional semiconductor laser, the breadth of the reflected light becomes small. Therefore, in the semiconductor laser of the structure of this invention, loss of a resonator becomes small and a threshold current is reduced.

[0014] Drawing 2 shows distribution of the field strength inside the resonator of the semiconductor laser of this invention, and the usual DFB laser.
[0015] In the case of the usual DFB laser, the field strength of the direction of a resonator is uneven like drawing 2 (b). On the other hand, in the semiconductor laser of this invention, as shown in drawing 2 (a), the homogeneity of the field strength distribution inside a resonator is improved. Therefore, the linearity of a current-optical output property improves in the semiconductor laser of this invention, and modulation distortion is reduced.
[0016] Moreover, if an electrode 7 is formed in some substrates 1, the selectivity of oscillation wavelength will become strong and single mode nature will improve.
[0017] Moreover, also by using the cladding layer 2 of substrate side 1 as a semi-conductor multilayers layer, the selectivity of wavelength becomes strong and single axial-mode nature improves.
[0018] Furthermore, an oscillation threshold current is reduced according to the effectiveness (the photon recycling effectiveness) that the spontaneous emmision light generated in the barrier layer 3 is returned to a barrier layer 3, by constituting the cladding layer 4 of another side by semi-conductor multilayers.
[0019] Moreover, effectiveness is improved by performing coating of a low reflection factor to the end face 5 of the direction which does not form a diffraction grating 6.
[0020]
[Example] Below, 1.3-micrometer band semiconductor laser which is one example of this invention is explained with reference to a drawing.
[0021] Drawing 3 is drawing showing the production process of the 1st example.
[0022] it is shown in drawing 3 (a) -- as -- the n-InP substrate 10 top -- MOVPE -- the DBR layer 12 which forms the n-InP buffer layer 11 in the thickness of 2000A by law, and makes one period n-InGaAsP (1024A in thickness) and n-InP (1024A) of 1.2-micrometer wavelength presentation -- about 3 micrometers -- forming -- the InGaAsP barrier layer 13 of 1.3-micrometer wavelength presentation -- 2000A grows about 2 micrometers and the p-InGaAs cap layer 15 in the DBR layer 14 of p mold further.
[0023] Subsequently, as shown in drawing 3 (b), a photoresist 16 is applied, and the 45-degree field 17 is formed by exposure, development, and etching.
[0024] Furthermore, as shown in drawing 3 (c), a photoresist 18 is applied, and after exposing and developing negatives so that a photoresist may remain only in the part of a 45-degree field, the p lateral electrode 19 and the n lateral electrode 20 are vapor-deposited.
[0025] Next, as shown in drawing 3 (d), lift off removes the electrode of a 45-degree field, and the pattern of a diffraction grating is formed by the interference exposing method using the photoresist 21 which remained in the 45-degree field again.
[0026] Then, as shown in drawing 3 (e), a diffraction grating 22 is formed by etching. Furthermore, the photoresist which exposed the whole surface, developed negatives and remained is removed.
[0027] Then, cleavage of the component is carried out in the part shown by the dotted line of drawing 3 (e).
[0028] As a result of oscillating this component by 1.31 micrometers, carrying out the modularization of the component made as an experiment and measuring the 3rd intermodulation distortion by two signals, -80dBc and a good distorted property were able to be acquired with the average fiber output of 5mW, and 20% of modulation factors.
[0029] When coating of 1% or less of reflection factor is performed to the end face of this component, the semiconductor laser of the former [effectiveness] has been improved 20% or more.
[0030] Next, the 2nd example is explained with reference to drawing 4 .
[0031] Drawing 4 is the structure which narrowed the part which constitutes the electrode 37 by the side of a substrate 1 from two parts, constitutes an electrode 37 in some substrates 1, and contributes to reflection of light. When such a component was produced like the case of the first example shown in drawing 3 , in the case of the conventional semiconductor laser, it was set to 30dBc(s) to submode oppression ratios having been 25dBc(s), and the single mode nature of an oscillation has been improved.
[0032] Furthermore, the 3rd example of this invention is shown in drawing 5 . This is the structure which made the cladding layer 42 by the side of a substrate 1 semi-conductor multilayers from the barrier layer 3. When the submode oppression ratio of this component is measured, it is 28dBc, and single mode nature improved rather than the conventional semiconductor laser.
[0033] Moreover, the 4th example of this invention is shown in drawing 6 . This is the structure which made the cladding layers 42 and 43 of the both sides of a barrier layer 3 semi-conductor multilayers. When such a component was produced, the oscillation threshold current was reduced 20%. Moreover, the submode oppression ratio was set to 30dBc(s).
[0034]
[Effect of the Invention] According to this invention, it becomes possible to offer the semiconductor laser for analog modulation of low distortion.

[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] Semiconductor laser characterized by consisting of optical waveguide which consists of a barrier layer formed on the semi-conductor substrate, and a cladding layer which sandwiches this barrier layer, an end face formed so that the include angle of about 90 degrees might be made to the shaft of said optical waveguide, and a diffraction grating which is prepared so that the include angle of about 45 degrees may be made to the shaft of said optical waveguide, makes the include angle of about 45 degrees to said end face, and is prepared in it on both sides of this optical waveguide in between.
[Claim 2] Semiconductor laser according to claim 1 characterized by dividing and forming the electrode by the side of a substrate in at least two parts.
[Claim 3] Semiconductor laser according to claim 1 or 2 characterized by constituting said cladding layer by semi-conductor multilayers.
[Claim 4] Semiconductor laser according to claim 1 to 3 characterized by performing coating of a low reflection factor to said end face.

[Translation done.]

* NOTICES *

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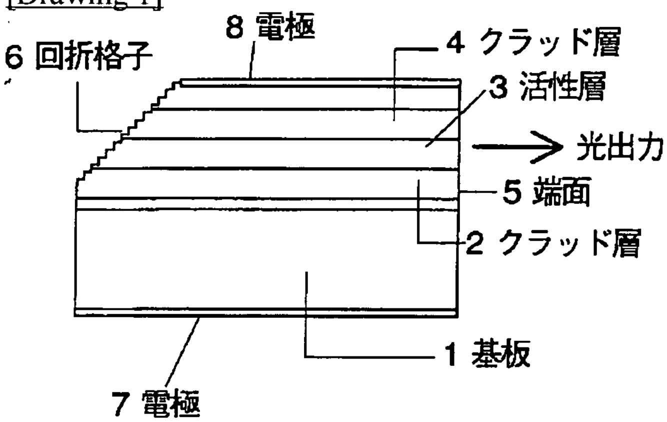
damages caused by the use of this translation.

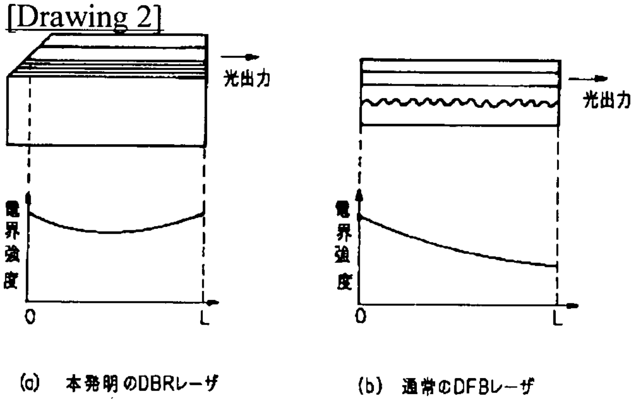
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

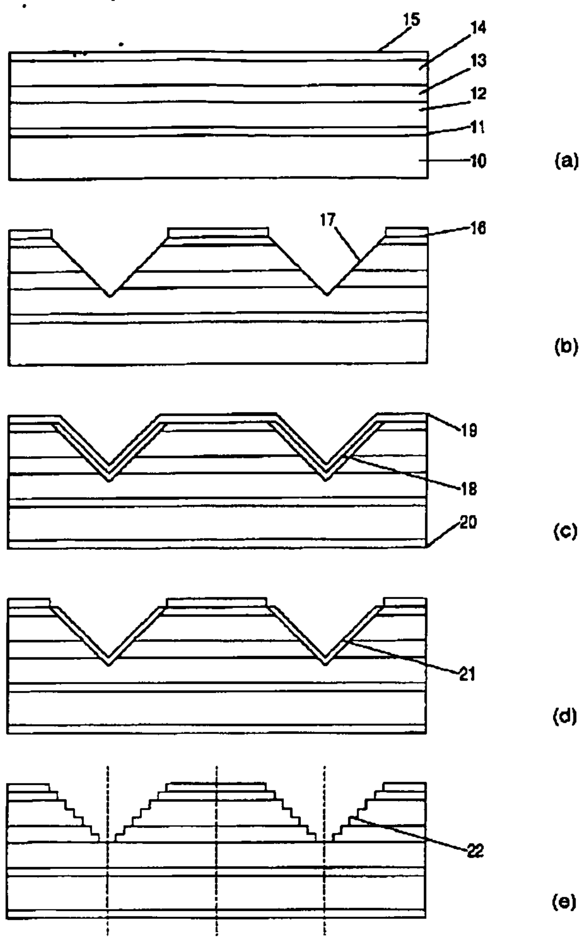
[Drawing 1]



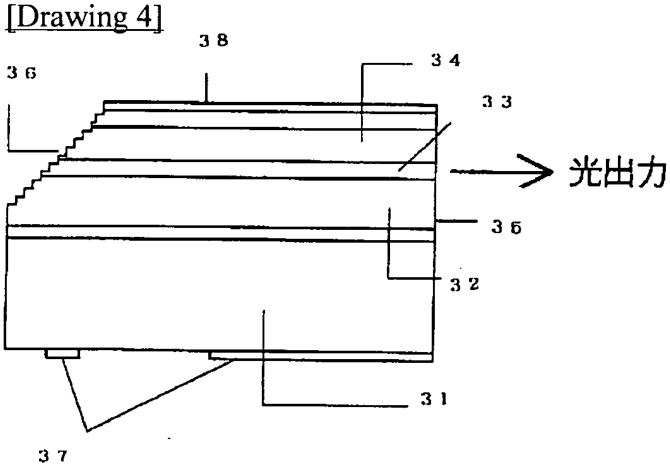
[Drawing 2]



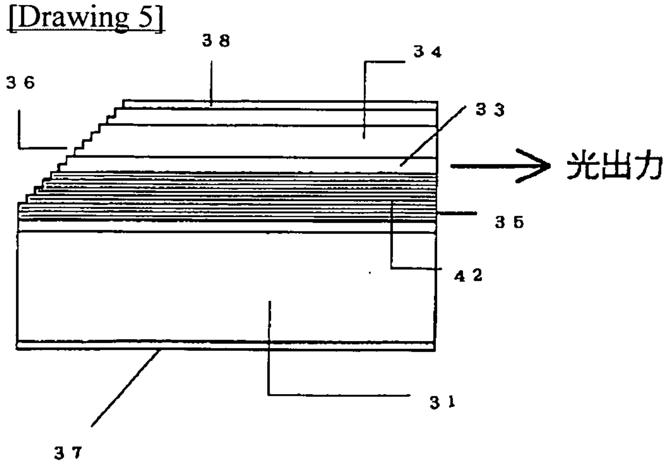
[Drawing 3]



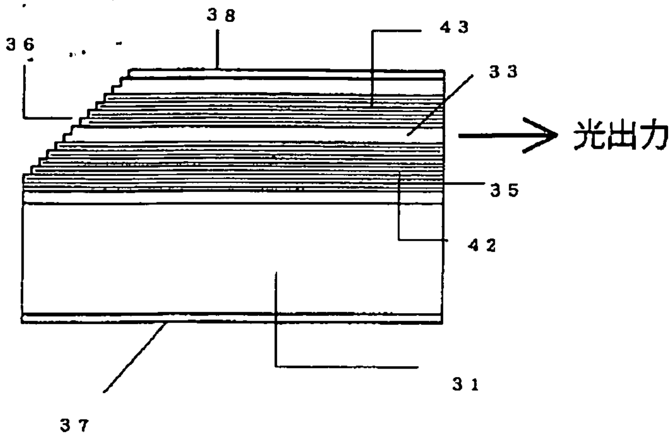
[Drawing 4]



[Drawing 5]



[Drawing 6]



[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing showing the theoretic structure of semiconductor laser which becomes this invention.
[Drawing 2] Drawing showing field strength distribution with the laser which becomes this invention, and the conventional laser.
[Drawing 3] Drawing for explaining the production process of the 1st example of this invention.
[Drawing 4] The sectional view showing the structure of the 2nd example of this invention typically.
[Drawing 5] The sectional view showing the structure of the 3rd example of this invention typically.
[Drawing 6] The sectional view showing the structure of the 4th example of this invention typically.
[Description of Notations]
1 Substrate
2 Cladding Layer (Substrate Side)
3 Barrier Layer
4 Cladding Layer (Growth Phase Side)
5 End Face Perpendicular to Shaft of Waveguide
6 Diffraction Grating Formed in Field Which Makes Include Angle of 45 Degrees on Shaft of Waveguide
7 Substrate Lateral Electrode
8 Growth Lateral Electrode
10 N-InP Substrate
11 N-InP Buffer Layer
12 N-InP Cladding Layer
13 InGaAsP Barrier Layer
14 P-InP Cladding Layer
15 P-InGaAs Cap Layer
16 Photoresist
17 Field of 45 "
18 Photoresist
19 Electrode
20 Electrode
21 Photoresist
22 Diffraction Grating
31 N-InP Substrate
32 N-InP Cladding Layer
33 InGaAsP Barrier Layer
34 P-InP Cladding Layer
35 End Face
36 Diffraction Grating
37 Electrode
38 Electrode
42 N Mold DBR Layer
43 P Mold DBR Layer

[Translation done.]